



# **VFP Sponsored Research Projects**

**By**

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**DOE-Visiting Faculty Program & BNL - Presentation**

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❖ Introduction

❖ Year 1 : I-DLTS

❖ Year 2 : Flash Atomization

❖ Year 3: Development of Fuel Atomizers for Low Firing Rate Modulating Burners

❖ Acknowledgements

# Introduction



Bachelor of Science in Aerospace Engineering  
University at Buffalo



Master of Science in Aerospace Engineering  
University at Buffalo

Master of Science in Mechanical Engineering  
University of Alabama in Tuscaloosa



Doctoral of Philosophy in Mechanical Engineering  
University of Alabama in Tuscaloosa



# Research Interest

- ❖ Propulsion
- ❖ Flash Atomization
- ❖ Improving the efficiency of the jet fuel used by the Air Force
- ❖ Improvement of Cadmium Manganese Telluride and Cadmium Zinc Telluride Nuclear Detectors for Homeland Security Applications
- ❖ Current Deep Level Transient Spectroscopy (I-DLTS)
- ❖ Cold-Start
- ❖ Fuel Vaporization
- ❖ Combustion
- ❖ Diesel engine
- ❖ Alternative fuel
- ❖ Internal Combustion engine emissions reduction and efficiency improvement
- ❖ Advanced Combustion IC engine concepts
- ❖ Laser diagnostics in an internal combustion engine
- ❖ Heat Transfer & Thermodynamics
- ❖ Images processing
- ❖ Humanoid robot



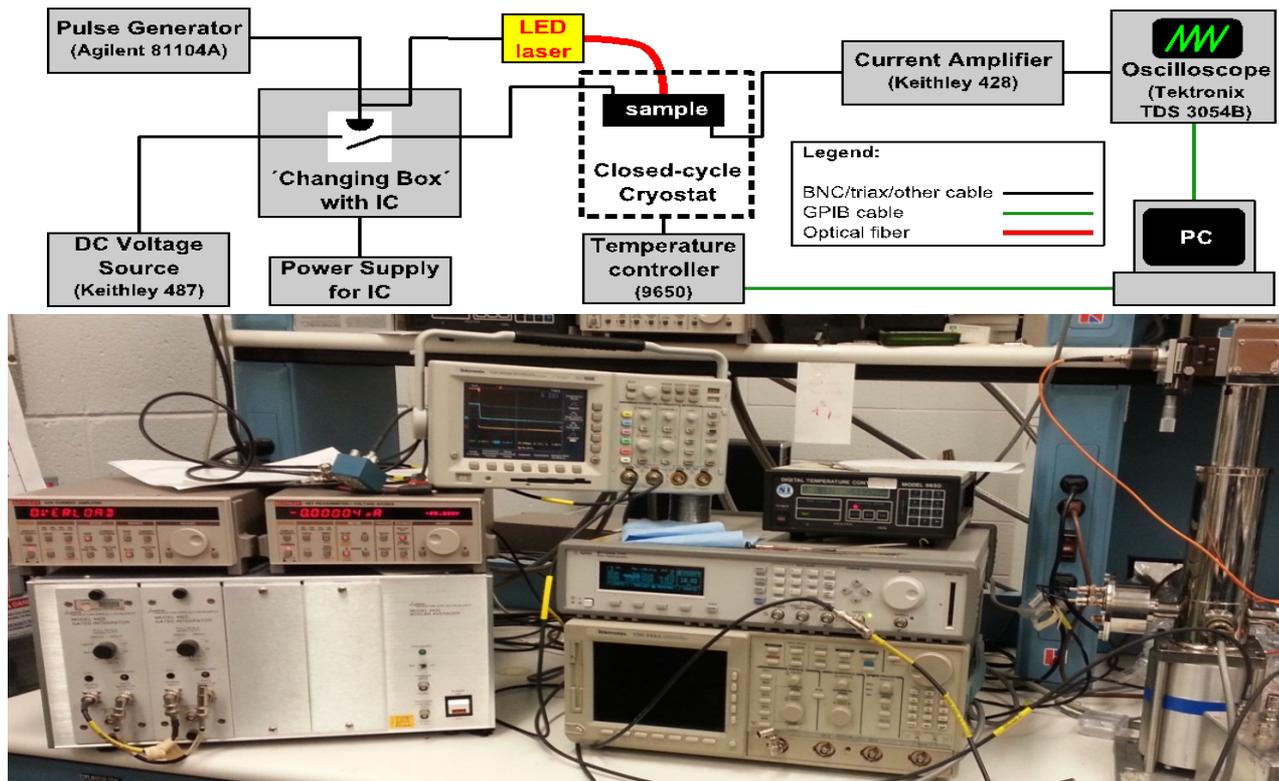
# **Year 1: I-DLTS**

# Current Deep Level Transient Spectroscopy(I-DLTS)

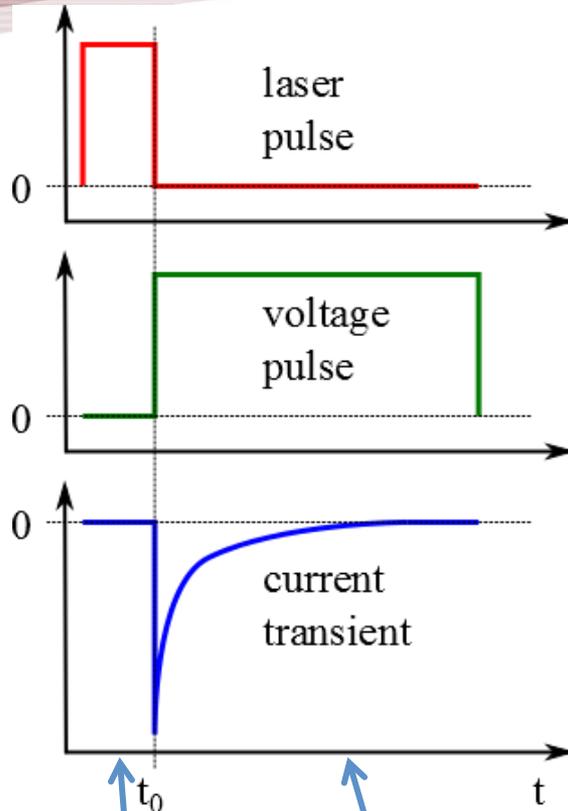
## ❖ I-DLTS

- current-based microscopic defect analysis technique for high resistivity detector materials( $> 10^6 \Omega\text{-cm}$ ) such as CdZnTe and heavily irradiated Si.
- Defects are filled by free carriers generated by incident laser pulse.

- ❖ This technique makes it possible to identify & analyze defect levels and their correlation with the detector electrical degradation



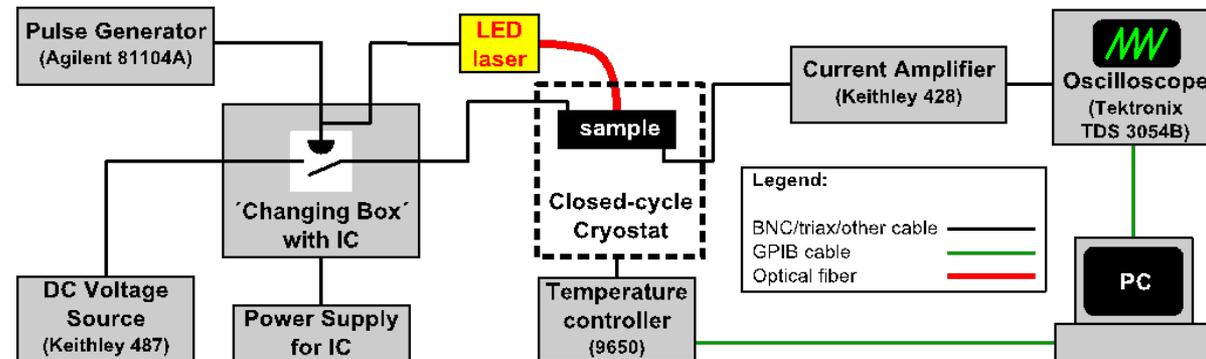
# I-DLTS Study



- I-DLTS ... Current Deep-Level Transient Spectroscopy
- Study of energy levels is important to get information about the defect structure in semiconductor materials
- Deep levels can negatively influence detector performance (low efficiency, poor energy resolution, and polarization)
- We can obtain **activation energy** and **capture cross-section** of defect levels

Defect-level filling

detrapping



Temperature range 12 - 360 K

# Summary



## ❖ Finished with

- I-DLTS manual for Drs. Ralph James & Zheng Li
- I-DLTS Data Analysis manual

## ❖ Collaborating with Dr. Budak's group at AAMU

- I-DLTS on new **sample's materials**
  - ✓ Resistivity?
    - It changes depending on the sample type
    - It depends on the applied high energy ion beam for bombardment
  - ✓ Band-gap
  - ✓ Bulk / Film
  - ✓ Dimensions
    - 2mm X 7mm or 1cm X 1cm

# Acknowledgements



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National Science Foundation/Domestic Nuclear Detection Office ARI(Academic Research Initiative) Program Entitled: ARI-MA Development of Improved CMT & CZT Nuclear Detectors for Homeland Security Applications

Radiation Research Groups at Brookhaven National Laboratory



## **Year 2: Flash Atomization**

# Objective for this research



- ❖ Help aid in the future transition to biofuel technology
- ✓ The outcomes include using a nozzle spray characterization to adjust the spray atomization process



- ❖ A pure liquid, a liquid mixture, or a liquid with dissolved gas is exposed to sufficient superheating or pressure reduction that causes bubble formation
  - ✓ Rapid growth of bubbles is the cause of the explosion of the bubble and generation of finer droplets and spray

# Why are Spray Important?



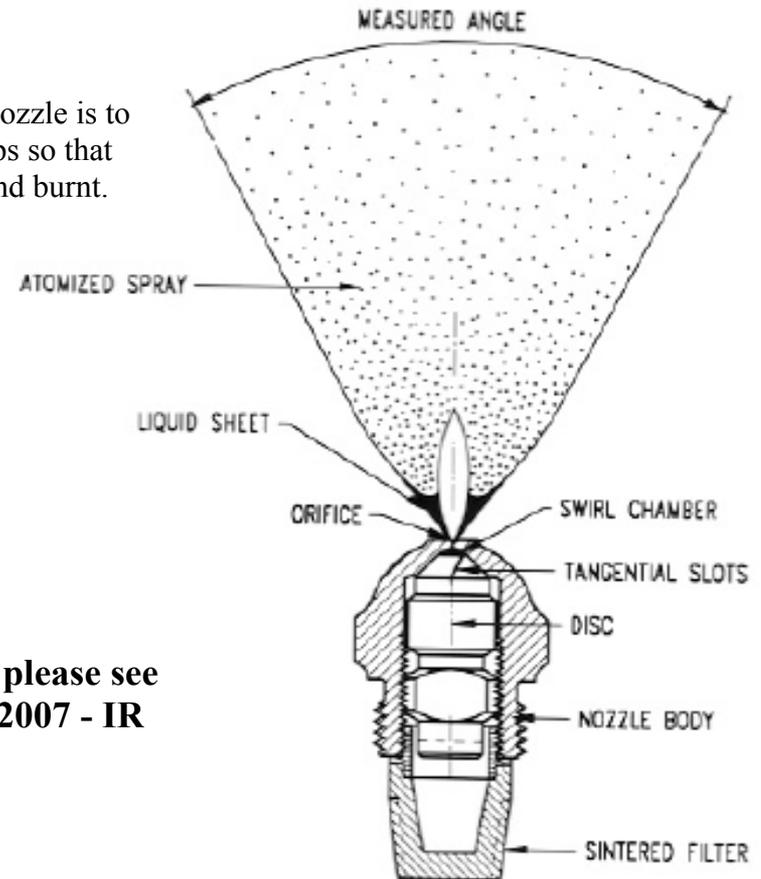
- ❖ Combustion of liquid fuels
  - ✓ Liquid rockets, liquid fueled ramjets
  - ✓ Diesel engines, stratified-charge engines
  - ✓ Oil-fired furnaces & boilers
  - ✓ Gas turbine
- ❖ Liquid metal processes
  - ✓ Powder production and net- form manufacturing (spray forming)
    - Requires precise control of droplet size and trajectory to obtain the desired performances
- ❖ Agriculture
  - ✓ Insecticides, fertilizer & pesticides
    - Need Correct droplet of size to achieve the desired goal
- ❖ **Application of health care products**
- ❖ Environmental protection
  - ✓ Water injection for NO<sub>x</sub> reduction
  - ✓ Gas scrubbing for dust particles
- ❖ Coating & Painting

- ❖ Important Liquid properties for atomization
  - ✓ Surface tension
  - ✓ Density
  - ✓ Dynamic viscosity

# Nozzle



Primary function of the nozzle is to atomize the fuel into drops so that they can be evaporated and burnt.



**For more info, please see  
BNL – 79185-2007 - IR**

Simplex Pressure Nozzle  
Photo Credit: Hago Manufacturing

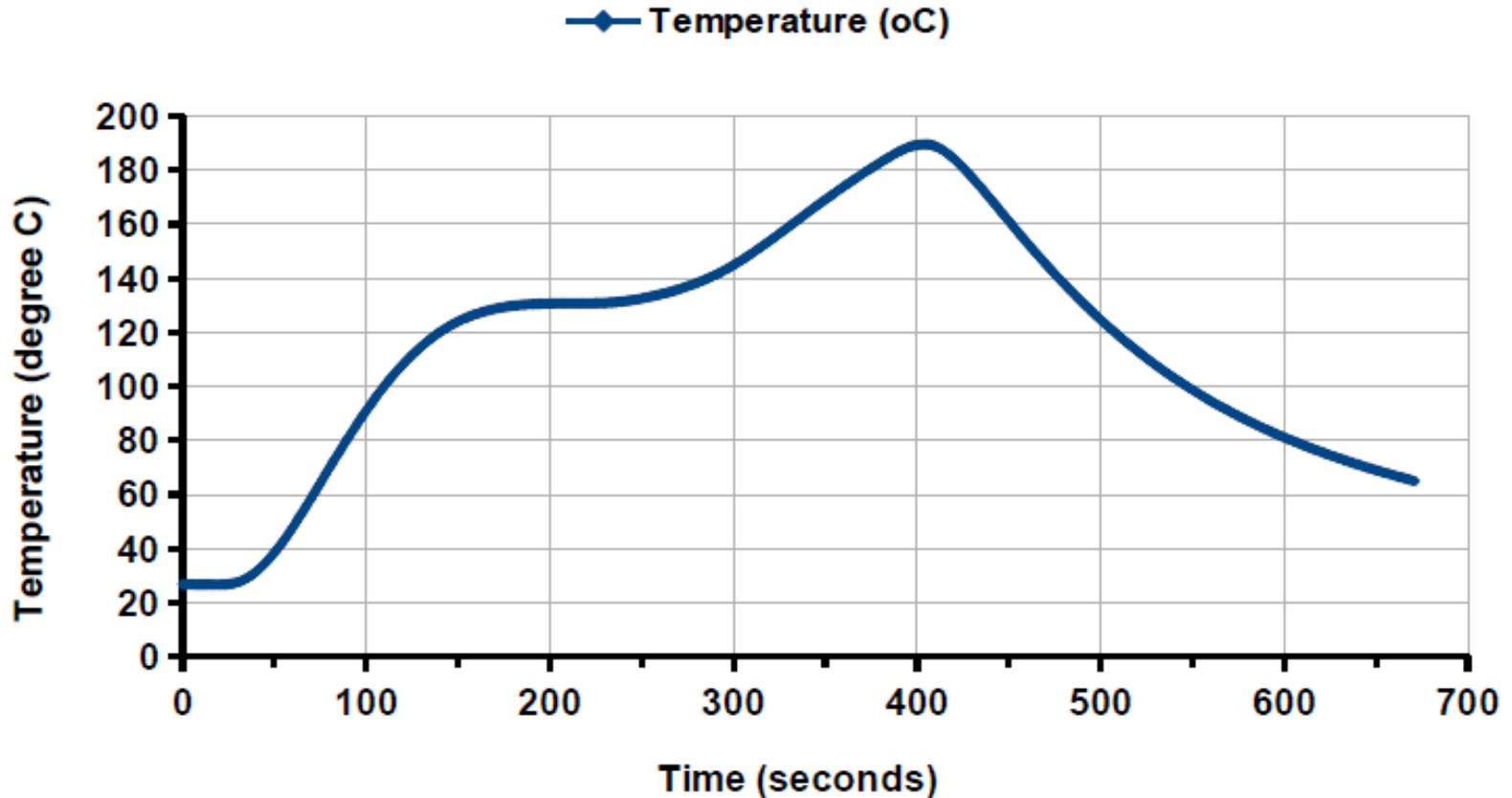
Nozzle Components, & Operation  
Photo Credit: Hago Manufacturing



**Analysis of Malvern Measurement Data For Danfoss  
45-degree 0.4 HFD Nozzle with number 2 heating oil  
@ 100 PSI**

## Transient Temperature History

Danfoss 45-Degree HFD 0.4 Nozzle with #2 Oil



- ✓ Tests with number 2 oil were performed under transient heating and cool down conditions.
- ✓ Smaller  $D[3][2]$  as the temperature goes up



- ❖ Wrote a proposal “**Development of Fuel Atomizers for Low Firing Rate Load Modulating Burners**” to National Oilheat Research Alliance(NORA)
  - It addresses the Category F: Atomization Technology of NORA Project Opportunity Notices (PON) NO. 2014-001
  - Funded

# Acknowledgements



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Sustainable Technology Research Groups at Brookhaven National Laboratory

- ❖ Drs. Thomas Butcher, Narinder Tutu, & C.R. Krishna
- ❖ George Wei & Yusuf Celebi



# **Year 3: Start working on the Funded Proposal**



**Suggestions Comments?**



# Nozzle



- ❖ Primary function of the nozzle is to atomize the fuel into drops so that they can be evaporated and burnt.
- ❖ The nozzle basically convert the potential energy that has been packed into the fuel in the form of pressure energy to kinetic energy, in the form of a swirling and extremely turbulent flow.
  - ❖ It causes the liquid sheet formed at the exit of the nozzle to break up into drops

